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Ranking of Poduction and Management Risks of Digital Resources in Digital Libraries by Means of Shanon Entropy and Fuzzy TOPSIS Techniques

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Abstract

Purpose:The current research has been done with a view to evaluation and ranking of production and management of digital resources in the supply chain of digital libraries. Method: Methodology of current research is essentially an applied one, and the method employed, has been descriptive survey based on Shanon Entropy and Fuzzy TOPSIS methods. Findings: According to our findings, the risks of "Collection development strategy of digital resources" with highest rate of Proximity Coefficient(PC)=%731 stand in the first place and then the other ones in order include: risks of "Management strategy of digital resources at libraries" with PC=%7186, "The high cost of technological changes of information carriers and storage formats" with PC=711 and "Competence of library software in detecting repetitious copies" with PC=%651. Conclusion : 26 risks for production and management of digital resources in the supply chain of digital libraries have been identified and amidst production and management risks of digital resources in the supply chain of digital libraries the risk of" Collection development strategy of digital resources" stands in the first place.

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Introduction

Digital libraries are centers that can deal with information services in many respects and pave the way for the optimal utilization of digital resources. The management of digital resources as a collective and organized approach, defines the method of collecting and using information so that digital libraries will be able to produce and manage the digital resources in proportion to the needs of users and their usefulness.

As regards the structure and principles, there are some similarities between the production and management of digital resources and their traditional counterpart. The change from traditional to digital has brought some risks about, however. The number of authors and publishers of printed resources is very high, heterogeneous and disperse, but thanks to the growth of knowledge and technology, we can control and identify this vast dominion to some extent. By comparison , the E-publication is a new ,immature and crude zone. Identification of all publishers, authors and producers of information besides all types of information resources has seriously challenged the producers and managers of digital resources(A digital strategy for the library of congress,2000)

The supply chain is defined as a network of independent and associate organizations which tries to manage the flow of material and information from suppliers to ultimate consumers through interaction and cooperation. What supply chain pursues is developing added value, producing high quality, affordable and update products and finally creating value for the customers.(MirFakhroldiny, Andalib and Rezayee Asl,2011)

Given the progress of knowledge and technology and the worldwide competitions of the modern age, the digital libraries are obliged to produce and manage a variety of resources in proportion to the demand of digital libraries` users. The production and management of digital resources at a high quality calls for a comprehensive supervision and monitoring which did not already exist. The production of digital libraries is resulted from integration and precise planning at the level of supply chain and the occurrence of risks at any part of supply chain especially the section “Production and management of digital resources” can cause disruption in the entire supply chain and not to mention some irreparable damages. In fact, taking the risks of production and management of digital

resources in the supply chain of digital libraries into consideration is regarded as a new attitude towards the selection of appropriate resources at an appropriate time for appropriate readers. The evaluation of supply chain risks in Iran has been mostly involved in industry and the industrial sector, and hence has received lots of attention from those active in the field. Jebel Amely and rezaeifar ,2007) have analyzed the different methods of multiple-index decision –making for ranking the risks of the project and have finally ranked the existing risks in a project of energy industry using the TOPSIS method and considering the four following criteria: occurrence probability, extent of effectiveness, uncertainty of estimates and the ability to respond. Shaghaghy & Naghshine(2009) worked on the generalization of Porter value chain to the activities of the specialized libraries and the effect of information technology on it(Shaghaghy & Naghshine,2009). Najla Hariry & Esmaeely Golsefidy(2015) investigated the analysis of the main processes of the supply chain management of Persian books at the libraries of Tehran`s Medical Sciences & Health Service University (Hariry & Golsefid,2015). Khorasany(2014) looked into the identification and evaluation of supply chain risks and prioritization of strategies to deal with them at Cruz corporation using the Fuzzy TOPSIS approach(Khorasany ,2014). Yary et al(2015) in their researches have identified and evaluated the risk of public libraries factors from Kermanshah`s public libraries ` librarians` points of view(yary and et.al ,2015). Marashy Shushtary et al(2018) investigated the establishment of the system of environment, health and immunity management(HSE-MS) at the launching phase of Sardasht dam, located in the northern range of Zagros using TOPSIS and Entropy techniques(Marashy Shushtary et al ,2018). Nadali Jolokhany et al(2018) evaluated and ranked the immunity risks of civil engineering projects carried out by Esfahan` municipality applying taxonomy technique and deconstruction approach (Nadali Jolokhany and et.al , 2018). Huang Meng et al(2010) presented the management model of supply chain for digital libraries (Huang Meng and et al ,2010). Ogden(2012) developed the prism software for risk evaluation and decision-making at libraries(Ogden,2012). Zhengbiao Han et al(2016) looked into risk evaluation of information security of digital libraries(Zhengbiao Han et al,2016).Ebijuwa & Oyelude investigated the strategies of risk management at cultural heritage institutes in

South Africa and West Nigeria(Ebijuwa & Oyelude,2016). Velasquez et al(2016) investigated risk management in the public libraries of South Australia(Velasquez and et.al , 2016). Prakash et al(2018) evaluated risks in the supply chain of manufacturing cars and developed a comprehensive, systematic and quantitative risk evaluation to measure the general risk behavior (Prakash and et al,2018). They used the AHP model which goes to show the relative importance of identified various factors in the risk evaluation of supply chain. According to their findings, we can use a well-organized and developed system to evaluate risks. As it is ascertained that no previous research has already been done into the concept of risk ranking in the production and management of digital resources in the chain supply of Tehran`s digital libraries, the present research is intended to identify the risks involving the production and management of digital resources in the chain supply of digital libraries to evaluate and rank them and also to increase the libraries` competence in dealing with risks. To achieve the above-mentioned goals, we are intending to answer the following questions:

1- What are the risks involving the production and management of digital libraries in the supply chain of digital libraries at Tehran`s state universities?
2- How are the risks involving the production and management of digital libraries in the supply chain of digital libraries at Tehran`s state universities analyzed and ranked?

Methodology

As regards purpose , the present research is an applied one, and as regards method, it is a descriptive survey using Shanon Entropy and Fuzzy TOPSIS. The tool for data collection has been research-made questionnaire. The statistical population comprises 20 university fully-experienced scholars and managers of digital libraries. Since hitherto no tool has been developed to assess the indexes of risks involving production and management of digital resources in the supply chain of digital libraries, the preliminary items for the assessment of risk indexes were extracted from the theoretical principles and experts` views then the indexes of the identified risk were sent to the experts and specialists of digital libraries and their views were received and investigated at different stages and steps; the categories related to any of the items were extracted and they were formulated as a

questionnaire in the format of a five-item Likert Scale based on the four following criteria: “Occurrence probability”, “Extent of effectiveness”, “Estimate certainty” and “Organizational inability to respond”. Then they were distributed among 18 specialists and managers of digital libraries at universities. The “Occurrence probability” criterion shows that the person who has estimated the occurrence of the risk, anticipates it. The “Extent of effectiveness” is how much(from a bit to a lot) a risk once occurred, has effect on the function and goals of digital libraries. The “Estimate certainty” criterion displays how much(a little, fairly, not at all) the person analyzing the results of estimating risk evaluation rates ,trusts them and the “Organizational inability to respond” shows the incapability of the organization to predict the occurrence of the risk and to get ready to tackle it. The two criteria “Occurrence probability” and “Extent of effectiveness” are both positive ie the higher the rate, the more important the risk will be in the evaluation, but the other two criteria are negative, that is to say, the higher the rate, the less important the risk will be for management. At the second stage to investigate the importance and weight of experts` views regarding risks of digital resources production and management, the Shanon Entropy technique was applied, and for ranking and prioritization of risks the Fuzzy TOPSIS software was utilized . First using the TOPSIS software, the distance between any of the risks and the ideal solution and minus ideal solution was calculated and accordingly the risks were prioritized and the risks that threatened the production and management of digital resources in the supply chain of digital libraries most, were determined then the proximity coefficient of ideal solution came out, finally the risks were ranked. The rate of Cronbach Alpha for the overall reliability of the questionnaire was %96 which denotes a strong reliability among the existing components of the quertionnaire.

Findings

Question.1 What are the risks involving the production and management of digital libraries in the supply chain of digital libraries at Tehran`s state universities?

Based on studies and a survey of the researche`s background and experts` views, 26 risks in the production and management of digital

resources in the supply chain of digital libraries at Tehran`s state universities were identified as presented by table 1:

Table.1. Risks of production and management of digital resources in the supply chain of digital libraries.

Number	Risks of production and management of digital resources	Number	Risks of production and management of digital resources
1	Management strategy of digital resources at libraries	14	Using Standard update portable storage medium
2	Collection development strategy of digital resources	15	Using Standard update mass storage medium
3	Tools to control documentations for coherence in the description of digital resources	16	Library software backing up metadata standards of digital resources
4	The function of security plans to tackle malwares	17	Storage formats of digital resources
5	Partial connection between bibliographic websites and documentation website at library software	18	Appropriate protocols for the interoperability of digital libraries systems
6	Librarians` extent of knowledge ability and update storage and processing of digital resources	19	Partial migration of data from one hardware to another for the digital preservation of resources
7	Carelessness and low exactitude of those in charge of organizing digital resources	20	Physical location of data-centers and digital library servers
8	Inappropriate organization and processing of all sorts of digital resources	21	High cost of technological changes of information carriers and storage formats
9	Specialized staff to digitize digital resources	22	Usability of back-up copies of digital resources
10	The control of digital library metadata by librarians	23	Having control over storage environments
11	Partial control of different copies of digital resources	24	Data theft at libraries
12	Competence of library software to detect repetitious copies	25	The long period of time required to retrieve lost resources
13	Software competence in the storage of digital resources with high capacity	26	Infrastructural problems in supplying digital resources such as inaccessibility wide-based internet lines and highly frequent disconnections of the network.

After a survey of the scientific texts and experts` views of digital libraries, 26 risk indexes relating to production and management of digital resources were identified which somehow threatened to damage digital libraries.

Question 2. How are the risks involving the production and management of digital libraries in the supply chain of digital libraries at Tehran`s state universities analyzed and ranked?

To assess and rank risks of production and management of digital resources in the present research the Fuzzy TOPSIS method was applied. The fuzzy figures and expressions applied in this research are presented by table 2:

Table 2. The relationship between the expressions and their amounts.

Expressions	Amounts
extremely high	(0,6,0,8,1)
high	(0,4,0,6,0,8)
medium	(0,2,0,4,0,6)
low	(0,0,2,0,4)
extremely low	(0,0,0,2)

In this research to obtain the weight of experts` views, Shanon Entropy method was applied. The method consists of 6 steps and the weighting of risks was done based on 4 criteria.

Table 3. Decision Matrix based on experts` views

	1	2	000	18
1	(0,6,0,8,1)	(0,4,0,6,0,8)	0	(0,6,0,8,1)
2	(0,6,0,8,1)	(0,4,0,6,0,8)	0	(0,2,0,4,0,6)
3	(0,4,0,6,0,8)	(0,2,0,4,0,6)	0	(0,6,0,8,1)
000	000	000	0	000
22	(0,6,0,8,1)	(0,6,0,8,1)	0	(0,6,0,8,1)
23	(0,6,0,8,1)	(0,2,0,4,0,6)	0	(0,2,0,4,0,6)
24	(0,6,0,8,1)	(0,4,0,6,0,8)	0	(0,4,0,6,0,8)
26	(0,6,0,8,1)	(0,4,0,6,0,8)	0	(0,6,0,8,1)

In this matrix there have been 26 variables and 18 experts. The results of the six steps of Shanon Entropy are presented by table 4:

Table 4 .Weighting of experts` views

Criteria	Occurrence probability	Extent of effectiveness	Estimate certainty	Library`s inability to respond to the risk	Criteria	Occurrence probability	Extent of effectiveness	Estimate certainty	Library`s inability to respond to the risk
1	2/9412	3/2353	3	2/7059	14	2/4706	3/1176	3/0588	2/5882
2	3/2353	3/1176	2/8824	2/8824	15	2/7059	2/9412	2/5294	2/8824
3	2/7647	3	2/5294	3/0588	16	2/6471	2/9412	3	2/9412
4	2/6471	3/1765	2/4118	2/8235	17	2/5882	3/2353	3/1765	2/7059
5	2/7647	3/2941	2/8824	2/7059	18	2/3529	2/7059	2/5294	2/2941
6	2/7059	2/8235	3/2941	2/7647	19	2/3529	2/6471	2/5882	2/6471
7	2/2353	2/9412	2/6471	3/1765	20	2/3529	2/8824	2/7647	2/8824
8	2/0588	2/7059	2/8235	2/5882	21	2/7059	3/2353	2/6471	2/4118
9	2/9412	3	3/1176	2/5882	22	3	2/8824	2/7059	2/7059
10	2/8824	2/5294	2/3529	2/8824	23	2/4706	2/8824	2/9412	2/7059
11	2/8235	2/7059	2/3529	2/9412	24	2/4706	2/6471	2/6471	2/8824
12	3	3/2353	2/6471	2/9412	25	2/3529	2/5294	2/4706	3/0588
13	2/8235	2/7647	2/8824	2/4706	26	2/1765	2/8824	2/6471	3

After obtaining the weight coefficient of experts` views(presented by table 4), we proceed to the normalization of the matrix as it is presented below by table 5:

Table 5. The unscaled weighted fuzzy matrix

Criteria	Occurrence probability	Extent of effectiveness	Estimate certainty	Library`s inability to respond to the risk	Criteria	Occurrence probability	Extent of effectiveness	Estimate certainty	Library`s inability to respond to the risk
1	0/2178	0/2163	0/213	0/1905	14	0/1829	0/2084	0/271	0/1822
2	0/2395	0/2084	0/2046	0/2029	15	0/2003	0/1966	0/1796	0/2029
3	0/2047	0/2005	0/1796	0/2153	16	0/196	0/1966	0/213	0/207
4	0/196	0/2123	0/1712	0/1988	17	0/196	0/2163	0/2255	0/1905
5	0/2047	0/2202	0/2046	0/1905	18	0/1742	0/1809	0/1796	0/1615
6	0/2003	0/1887	0/2338	0/1946	19	0/1742	0/1769	0/1837	0/1863
7	0/1655	0/1966	0/1879	0/2236	20	0/1742	0/1927	0/1963	0/2029
8	0/1524	0/1809	0/2004	0/1822	21	0/2003	0/2163	0/1879	0/1698
9	0/2178	0/2005	0/2213	0/1822	22	0/2221	0/1927	0/1921	0/1905
10	0/2134	0/1691	0/167	0/2029	23	0/1829	0/1927	0/2088	0/1905
11	0/2091	0/1809	0/167	0/207	24	0/1829	0/1769	0/1879	0/2029
12	0/2221	0/2163	0/1879	0/207	25	0/1742	0/1691	0/1754	0/2153
13	0/2091	0/1848	0/2046	0/1739	26	0/1611	0/1927	0/1879	0/2112

To normalize the matrix, we divided each amount into the vector of the same index. All the resulted figures were within the 1-0 range. Thus, the indexes of production and management of digital resources And then in the next step, it is *A*+ $\tilde{v}_j^+ = (1,1,1) \quad and \quad \tilde{v}_j^- = (0,0,0) \quad j = 1,2,\ldots,n.$ positive ideal fuzzy and *A*- negative ideal fuzzy as follows:

If *A* and *B* are two fuzzy numbers as follows, then their interval will be calculated by the following formula.

$$\widetilde{A} = (a_1.b_1.c_1)$$
$$\widetilde{B} = (a_2.b_2.c_2)$$

$$D(A.B) = \sqrt{\frac{(a_2 - a_1)^2 + (b_2 - b_1)^2 + (c_2 - c_1)^2}{3}}$$

Then as we go on, we use the following formula to find the interval from the ideal.

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$$d_i^* = \sum_{j=1}^{n} d\,(\tilde{v}_{ij} - \tilde{v}_j^*) \qquad i = 1.2.000.m$$

$$d_i^- = \sum_{j=1}^{n} d\,(\tilde{v}_{ij} - \tilde{v}_j^-) \qquad i = 1.2.000.m$$

Finally, the following equation is used to find the relative proximity of the i^{th} element to the positive ideal.

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}$$

The risks may be rated based on the descending order. The greater the CC_i a risk has, the better. The Topsis technique phases were then implemented using triangular fuzzy numbers described in table 3. After the data analysis and finding the steps of the fuzzy Topsis technique, the risks of digital sources production and management for supplying the digital library sources were rated. Table 6 indicates the results of the risks rating process.

Table 6. Ranking of digital resources production & management risks in the supply chain based on Fuzzy TOPSIS technique.

Index	Distance to ideal solution	Distance to minus ideal solution	Proximity coefficient	Rank
Collection development strategy of digital resources	0/0126	0/0341	0/731	1
Management strategy of digital resources at libraries	0/0155	0/027	0/7186	2
High cost of technological changes of information carriers and storage formats	0/0156	0/0251	0/711	3
Competence of library software to detect repetitious copies	0/0117	0/03	0/651	4
Usability of back-up copies of digital resources	0/0175	0/0249	0/6375	5
Tools to control documentations for coherence in the description of digital resources	0/0118	0/029	0/6353	6
Partial connection between bibliographic websites and documentation website at library software	0/0168	0/0248	0/6171	7
Specialized staff to digitize digital resources	0/0171	0/0237	0/602	8
Partial control of different copies of digital resources	0/0173	0/0261	0/5968	9
Using Standard update portable storage medium	0/0157	0/0276	0/593	10
Using Standard update mass storage medium	0/0172	0/0237	0/5872	11
The control of digital library metadata by librarians	0/0155	0/0289	0/581	12
Software competence in the storage of digital resources	0/0166	0/0242	0/5797	13
Appropriate protocols for the interoperability of digital libraries systems	0/0255	0/0199	0/4484	14
Storage formats of digital resources	0/0241	0/0181	0/439	15
Using Standard update portable storage medium	0/0251	0/016	0/4359	16
Partial migration of data from one hardware to another for the digital preservation of resources	0/0262	0/0169	0/4293	17

Index	Distance to ideal solution	Distance to minus ideal solution	Proximity coefficient	Rank
Library software backing up metadata standards of digital resources	0/0222	0/018	0/4126	18
Usability of back-up copies of digital resources	0/0248	0/015	0/3922	19
Data theft at libraries	0/0243	0/017	0/3885	20
Librarians` extent of knowledge ability and update storage and processing of digital resources	0/0243	0/0188	0/3866	21
Physical location of data-centers and digital library servers	0/0269	0/014	0/3773	22
The long period of time required to retrieve lost resources	0/0278	0/0175	0/3428	23
Carelessness and low exactitude of those in charge of organizing digital resources	0/0303	0/0141	0/3169	24
Infrastructural problems in supplying digital resources such as inaccessibility wide-based internet lines and highly frequent disconnections of the network.	0/0312	0/0135	0/3022	25
Inappropriate organization and processing of all sorts of digital resources	0/0344	0/0117	0/2539	26

According to the table`s findings, in the first place stand risks of "Collection development strategy of digital resources" with Proximity Coefficient(=PC)=%731, then those of "Management strategy of digital resources at libraries" with PC=%7186, in the third place those of "The high cost of technological changes of information carriers and storage formats" with PC=%711 and finally in the fourth place stand the risks of "Competence of library`s software in detecting repetitious copies" with PC=%651, all of which have priority over the other risks of digital resources production and management in the supply chain of digital libraries .

Conclusion

As the supply chain of digital libraries is so extensive, it is always prone to a wide variety of risks. The risks often inflict a great deal of trouble and expenses upon the supply chain of digital libraries, so the

managers and experts of digital libraries invariably seek to manage risks in the supply chain. Production and management of digital resources is one of the most crucial stages of supply chain. The selection of information sources, collections evaluation, digitization processes, collection harmonization, etc are directly or indirectly related to the other sections of digital libraries supply chain including the section of services to users. The expansion of information sources, publishers, producers,etc in the digital libraries has rendered the managers of digital resources heavily confronted with a lot of risks, therefore, knowing about the risks and adopting strategies to prevent their occurrence greatly contributes to both competitiveness of digital libraries in the outside environment and to the increase of final users` satisfaction.

The present research which aimed at the evaluation and ranking of risks involving the production and management of digital resources in the supply chain of digital libraries, based on a survey of scientific texts, studies and experts` views, has identified 26 risk indexes concerning production and management of digital resources at digital libraries. According to the results, some of the most important indexes of those risks include: cost, quality, high cost of technological changes, information back-ups, using standard storage media and specialized staff to digitize the resources. The results of the present research are in the accordance with the researches done by Shaghaghy & Naghshinme(2009), Esmailee Golsefidy(2015), Yary et al(2015), Zhengbiao Han et al(2016) and Ebijuwa & Oyelude(2016). At analysis stage using the TOPSIS technique out of the 26 identified risks, the first four ranks were achieved by the following risks:1- collection development strategy of digital resources with PC=%731 . 2-management strategy of digital resources at libraries with PC=%7186. 3-high cost of technological changes of information carriers and storage formats with PC=%711. 4-competence of library software in detecting repetitious copies with PC=%651.

The above-mentioned risks have priority over the other risks involving production and management of digital resources in the supply chain of digital libraries. At assessment stage, the first four ranks were achieved by the following risks: 1- collection development strategy of digital resources 2- management strategy of digital resources at libraries 3- the high cost of technological changes of information carriers and storage formats 4- competence of library

software in detecting repetitious copies. The results of this part agree with the researches done by Jebel Amely et al(2007), Khorasany(2014), Marashy Shushtary et al(2016), Nadali Jolokhany et al(2019), Huang Meng et al(2010), Ogden(2012), Velasquez et al(2016) and Prakash et al(2018).

Optimal production and management of digital resources prevents us from wasting time and money at digital libraries. Given the fact that management of a risk does not necessarily mean its elimination; it is necessary therefore to do the best we can to turn red or dangerous risks into green or safe ones. In response to the risks of ”Collection development strategy of digital resources” digital libraries have the highest rate of occurrence probability and extent of effectiveness , thus they should develop a strategy for collection development of their digital resources, so that in the event of the occurrence of a risk as less harm as possible will befall the collection development of digital resources. As “Management strategy of digital resources at libraries” is in the second place amidst risks of digital resources production and management, the adoption of the right initiative to develop a certain strategy for the management of digital resources at digital libraries is suggested. Moreover, in response to the risks of “Competence of library software in detecting repetitious copies”, digital libraries have had a poor performance; and software errors have caused serious problems in the domain of digital resources production, therefore it is suggested the software errors be identified and necessary amendments be made to promote the function of digital libraries` softwares.

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